KINETIC STUDY OF ELECTRICALLY ACTIVATED REACTING SYSTEMS AT RELATIVELY LOW TEMPERATURE LEVELS

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A complete, critical review of the thermodynamic and kinetic behaviors of twenty-six reactions has been carried out and the following fourteen reactions have been selected for further investigation.

1. $H_2 + I_2 \rightleftharpoons 2HI$
2. $N_2 + 2C \rightleftharpoons C_2N_2$
3. $2NO_2 + H_2O \rightleftharpoons 2HNO_3 + NO$
4. $NO_2 + O_3 \rightleftharpoons NO_3 + O_2$
5. $NO + NO_3 \rightleftharpoons 2NO_2$
6. $2NO_2 + O_2 \rightleftharpoons 2NO_3$
7. $NO_3 + NO_2 \rightleftharpoons N_2O_5$
8. $O_3 + NO \rightleftharpoons NO_2 + O_3$
9. $NO + Cl_2 \rightleftharpoons NOCl$
10. $CO + NO_2 \rightleftharpoons NO + CO_2$
11. $CO + O_2 \rightleftharpoons 2CO_2$
12. $CO + O_3 \rightleftharpoons 2CO_2$
13. $N_2 + H_2 \rightleftharpoons NH_3$ (Uncatalyzed)
14. $H_2 + NO_2 \rightleftharpoons NO + H_2O$

The other reactions were rejected for their undesirable kinetic behaviors, having either uncertain mechanisms or uncontrollable rates. Among the above fourteen reactions the first

three have been classified for the next phase of this study since their kinetic behaviors under normal reaction conditions show that the application of the proposed activation techniques may generate very valuable data needed for testing and analyzing the theoretical aspects of the proposed technique.

The complete experimental planning has been made and the necessary equipment is being constructed for the first reaction, $H_2 + I_2 \rightleftharpoons 2HI$. The flow sheet of the process is attached. Iodine crystals are vaporized at a constant rate (1) and measured (2), then the vapor is preheated (3) to a temperature not above 600°C before entering the reactor (7). All the surfaces that the I_2 gas stream touches will have to be heated above 185°C, b.p. of I_2. The temperature of I_2 gas stream at the inlet of the reactor will be measured by potentiometer and thermocouples. The I_2 gas will be surface charged negatively by the porous electrode (4) made of stainless steel wool to which high voltage static negative charge is applied using a DC power supply (12). Similarly, H_2 gas will be supplied from a standard gas cylinder (16) and the flow rate will be regulated with a needle valve and measured with a rotameter (15). The H_2 gas is then preheated (14) to a temperature not above 600°C before entering the reactor. At the inlet, the H_2

gas will be surface charged positively by the porous electrode (5) using a separate power supply (13). A well-defined and uniform field will be established between the two electrodes, and the distance between the two electrodes may be varied as desired by moving one or both electrodes toward the center of the reactor. Thus, the potential across the two electrodes and the size of the reactor can be freely varied while maintaining a well-defined and uniform field. The charged species will move toward the electrode of opposite polarity and collide with the charged species of opposite polarity since their flows are counter-current. The decomposed I and H atoms may also react and form HI. The charged species and any polar species will be oriented or even distorted according to the field established while they are travelling in their collision courses. The temperatures of reaction will be kept constant below 600°C in order to avoid the reverse reaction. The pressure in the reactor will be maintained at 1 atm. A part of the products will be drawn out steadily through glass wool packing (8), which promotes the collision of any charged species to neutralize them to prevent any further reaction between them. Then, the product gas mixture will be passed through a quencher (10) to bring them to the room temperature rapidly in order to prevent any possible

further reactions before it is accurately measured for its volume and mass and then sampled for analyses. The product gas will be analyzed by the techniques of chromatography and I. R. Spectroscopy. The reactor having the size of 2" I.D. x 24" is being made by the Corning Glass Company and the temperature of reaction will be maintained by radiant heaters in order to eliminate any secondary fields which may be developed by resistance-type heaters. In the quencher (10), the I_2 formed will be removed periodically and the remaining gas will then be analyzed for HI.

The technique described above has been developed based on the research experience gained by the principal investigator in the last seven years, in this field. It would permit studying quantitatively the effects (1) of ionization and of polarization by ionization, (2) of distortion by the imposed electric field, (3) of orientation in an electric field, (4) of energies and frequencies of collisions, and other electrostatic and electrodynamic interaction within and between molecules.

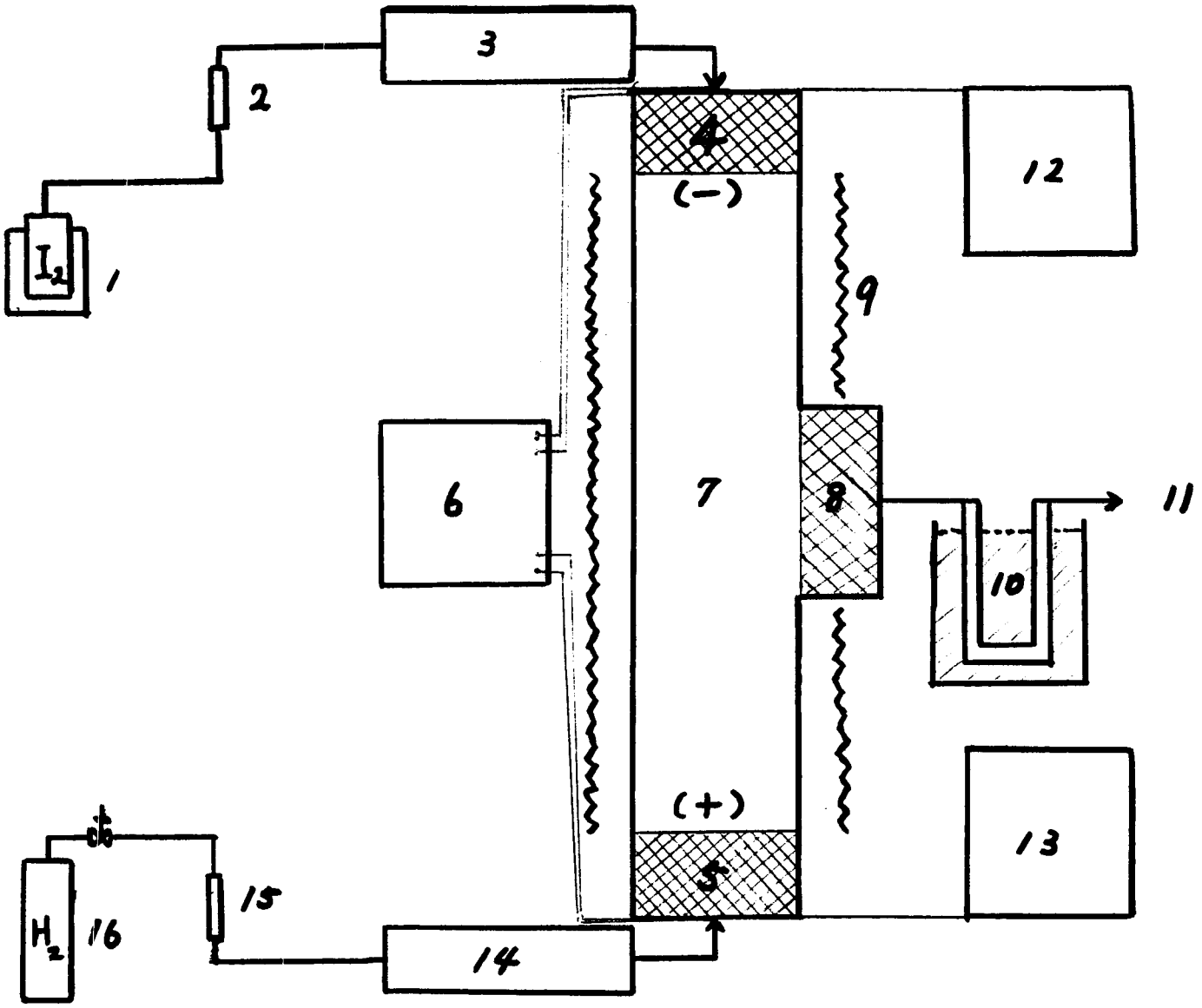
The details of the results will be included in the annual report due in September 1966.

The summary of some studies just completed by the principal investigator as an integral part of this research program but not

supported by NASA is also shown in the renewal proposal to be submitted to NASA in the immediate future.

Flow Sheet of $H_2 + I_2 \rightleftharpoons 2HI$ Reaction

1. I_2 vaporizer
2. Rotameter (I_2)
3. Preheater (I_2)
4. Negative porous electrode made of stainless wool.
5. Positive electrode made of stainless wool.
6. Potentiometer and thermocouples for temperature measurement.
7. Reaction zone
8. Glass wool packing - neutralization zone.
9. Radiant heater for temperature control.
10. Quencher.
11. To Rotameter and then sampling bottles.
12, 13. DC power supply.
14. Preheater (H_2)
15. Rotameter (H_2)
16. Hydrogen bottle.


3
2
4
12
I_2
1
(−)
9
6
7
8
11
10
(+)
5
13
H_2
16
15
14